CONTINUOUS PROCESS AND MACHINE

BACKGROUND OF THE PRESENT INVENTION

Liquid natural gas can be shipped in far less space than when it is in a gaseous state. However, such shipments must be at cryogenic temperatures, requiring insulated containers. To avoid embrittlement of the metal of the containers, the insulation should be inside, thermally shielding the container hull structure from the cold temperature of the liquid natural gas. When liquid gas seeps through the insulation and warms up to a gaseous state it expands and rips insulation from the container walls. For this reason a three-dimensional fabric reinforcement has been developed which contains the insulation foam in place until the pressure has stabilized. One such insulation is disclosed in Applicant's co-pending application Ser. No. 385,313 filed Aug. 3, 1973 for Multi-Layer Cryogenic Insulation. Another is disclosed in Applicant's co-pending application Ser. No. 385,314 filed Aug. 3, 1973 for Multi-Fabric Tufted Thread Reinforced Thermal Insulation. Still another is disclosed in U.S. Pat. No. 3,317,074 issuing May 2, 1967 to Barker et al. for Cryogenic Containers.

Current methods of manufacture relate to discontinuous processes that consume large volumes of excess materials, creating a disposal problem of solid waste. Both the use and the disposal add significantly to the cost.

An endless belt assembly structure has been developed for retaining layers of open weave netting in stacked spaced relationship as they move through a series of work stations in an assembly line production. This belt assembly is the subject matter of co-pending patent application Ser. No. 402,794 filed Oct. 2, 1973. Information concerning an exemplary insulation material and the endless belt assembly may be had from these applications.

SUMMARY OF THE PRESENT INVENTION

In accordance with the present invention there is provided a low cost method of manufacture for three-dimensional fiber reinforced insulation to meet the commercial demands for this product. This is a continuous process requiring a minimum of auxiliary materials. As long as raw materials are supplied, the three-dimensional insulation is of endless length. The channelling of the matrix and polymer during the expanding and setting of the foam minimizes trimming and trimming losses. This process uses a stack consisting of several layers of properly spaced woven, knitted or equivalent fabric that possesses interstices sufficiently large to permit the easy passage of commercial tufting needles and still produce a thread spacing in the fabric sufficient to supply the required reinforcement for the three-dimensional insulation. Commercial tufting needles can be procured that will pass through at least a five inch stack of spaced and layered fabric. The stack of fabric layers is fed into a moving belt system that grips each side of each layer of fabric simultaneously and at a fixed desired spacing from layer to layer. These layers are held taut as the fabric matrix is carried forward through a trough. Fibers are inserted through the stack of layers normal to the fabric surfaces by bottom tufting and the resultant rigidly held three-dimensional matrix is then foamed into a rigid closed cell polyurethane reinforced insulation structure. The art of foaming, per se in making such a structure is well known, since mattresses, seat cushions and many other articles are made for cushioning, insulation and other uses with such foaming techniques.

The bottom of the trough may be paper moving independently or riding on a moving belt or the belt alone may be used if made from a non-sticking elastomer. The sides of the trough will consist of the fabric-gripping moving belts. The top of the channel or trough may or may not be a moving belt. This technique controls the size of the block cross sectional area and will minimize trimming losses. Conventional cutoff and cross-sectional trims can be used as the material leaves the machine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of the continuous process machine,

FIG. **2** is a sectional view taken along the line **2—2** in FIG. **1**, and

FIG. **3** is a perspective view in section of an exemplary insulation material made by the present process and machine.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

Reference is now made to FIG. **1** which is a side view schematically represented. In this view there is shown a plurality of rolls **10, 12, 14, 16, 18** and **20** of a desired reinforcement fabric, gas vapor barrier material, open weave netting or other layers to be imbedded in the foam insulation. In one embodiment rolls **28** inches wide of open weave fabric was desirable. Rollers **22,** 24, 26, 28, 30 and **32** position layers **34, 36, 38, 40, 42** and **44** from the rolls in a vertical spaced relationship such that layer **34** is the top layer and layer **44** is the lowermost layer, with the other layers being spaced in between as desired. These layers pass through a trough which forms a pathway between horizontally spaced vertically oriented endless conveyor belts. Conveyor belt **46** is shown in FIG. **1** as the belt on the far side of the fabric layers from the viewer and the endless belt between the viewer and the fabric layers is not shown for purposes of clarity. These endless belts form the sidewalls of the trough and the edge portions of the fabric layers are held and moved by these belts. For example, in co-pending application Ser. No. 402,794, filed Oct. 2, 1973 for Continuous Belt System Holding Multiple Layers there is an illustration how the layer edges may be gripped within slits in the belt and moved along from station to station and then released from the belt at the end. Convex roller **48** at the commencement of the loop in the present application causes the slits to widen to receive these layer edges, after which the slits grip the layers and move them past the various work stations. Convex roller **48** indicates the end of the conveyor belt movement from which the return loop, not shown, commences.

The first step in making a three-dimensional reinforced strip, after the layers are vertically positioned, is to apply vertical stitching through the various layers. This stitching is represented by stitches **50** which are applied at a tufting station represented by tufting needle **52,** tufting machine **54** and the spool **56** of tufting thread. A plurality of tufting needles are spaced across the width of the layers so that multiple rows of stitching **50** are applied across the 28 inch wide fabric. Any